Comparison between using the deterministic package WIMSD/CITATION and the Probabilistic Monte Carlo codes for Neutronics and Burnup Calculations of Research Reactors

Presented By
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- My work interest is Nuclear Reactors safety Analysis

Introduction

- As we know the importance of safety analysis for any technology.
- The processes of safety analysis should be used in all stages; design, construction and operation.
- The basic approach to safety, is to specify criteria and then to design, construct and operate based on that criteria.
- That criteria will be descried with a number of parameters and quantities that determined through calculations and measurements.
- The values of those parameters should be accurate and in alignment with the experimental values.

Description of the work

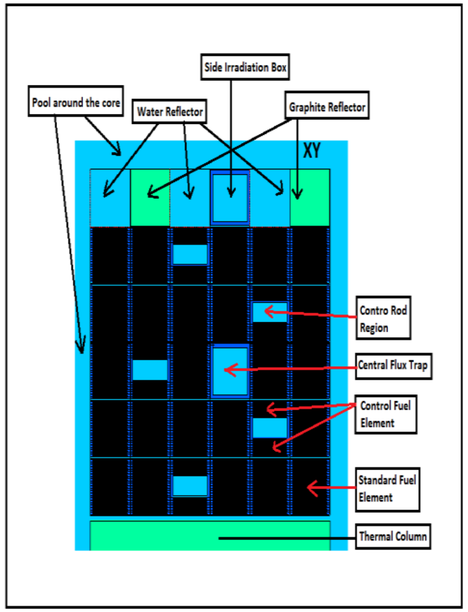
- In this work **a parametric study of some neutronic parameters** of selected research reactor cores has been shown. The two research reactors; PARR-1 & IAEA MTR 10 MW research reactor has been used as the selected type for this study.
- **A comparison between** the results obtained by using the **deterministic** package WIMSD/CITATION and the **probabilistic** Monte Carlo codes has been performed.
- The **results indicated** under estimation when using the deterministic package and over estimation by using the probabilistic Monte Carlo codes.

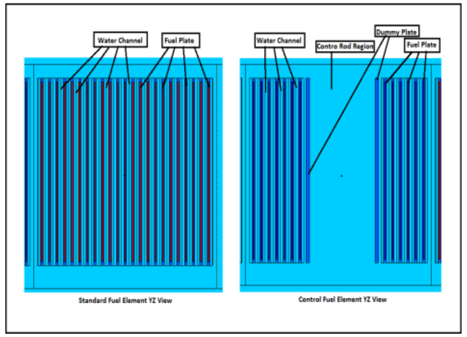
Methodology and Tools

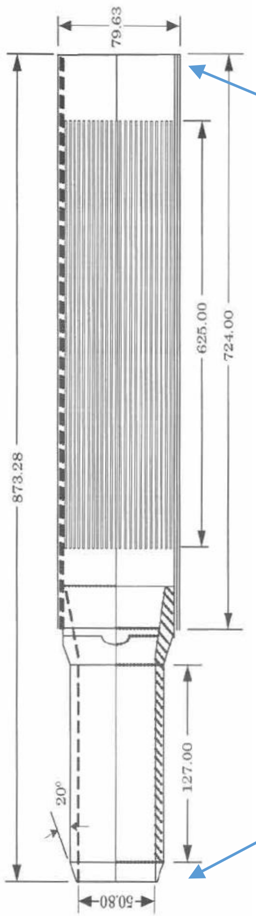
- The WIMSD code has been used for the lattice cell calculations and CITATION code for the whole core calculations.
- The 69 neutron energy groups of the standard WIMSD library has been condensed to 5 energy groups that cover the fast, resonance and thermal energy ranges.
- For the Monte Carlo calculations the ENDF library already delivered with the codes has been used.

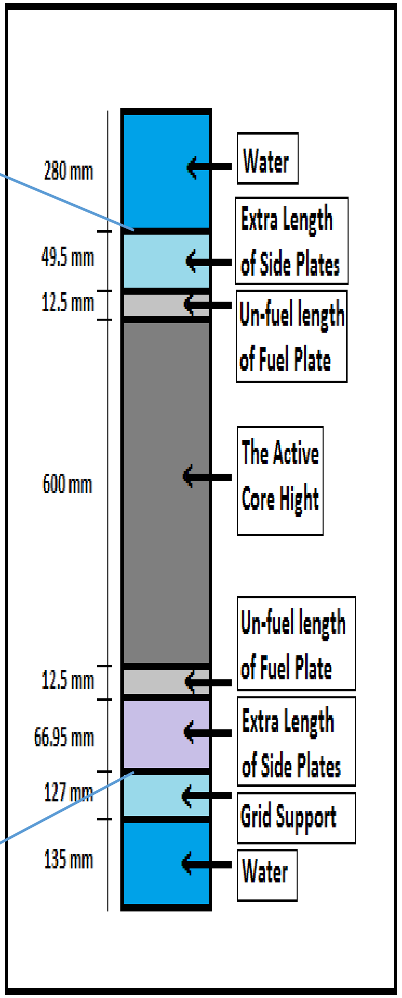
The core Description

- The core of PARR-1 consists of an assemblies of standard and control fuel elements mounted on aluminum grid plate.
- It use a fuel material **U_3Si_2-Al.**
- The standard fuel contained 1451g of total uranium.



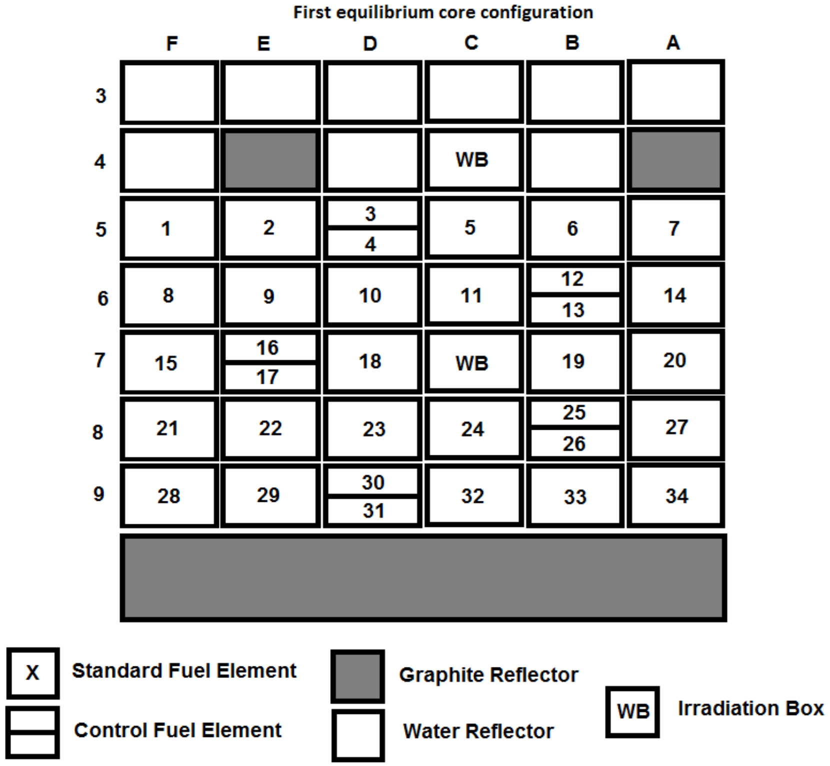




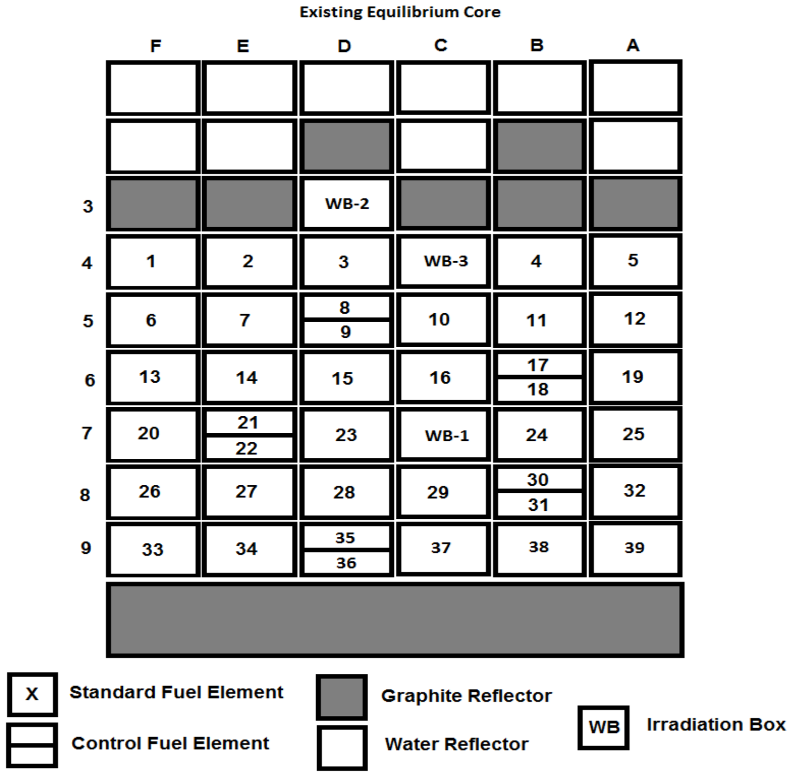


The Core Configurations

The First equilibrium Core of PARR-1

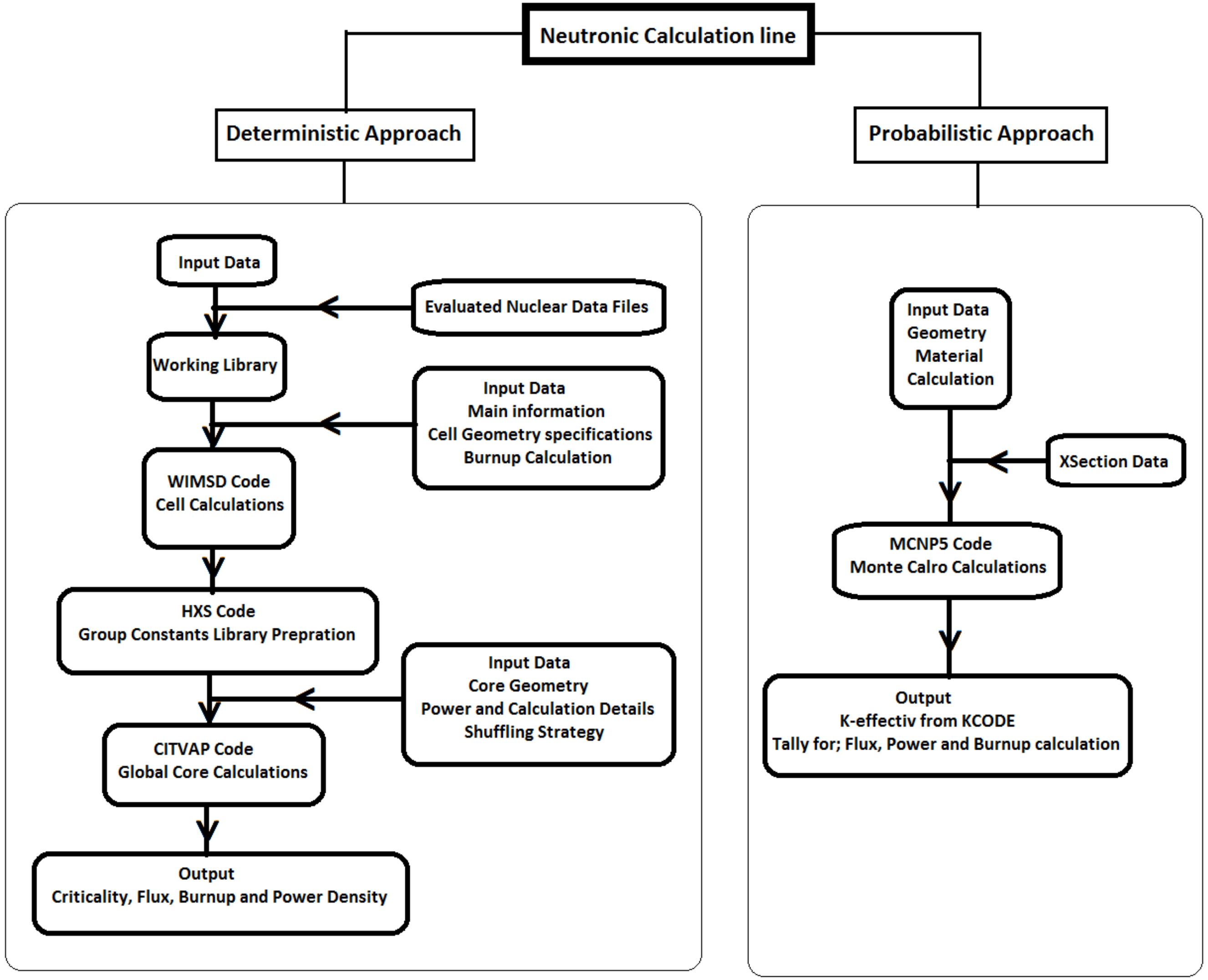


The Existing equilibrium Core of PARR-1



Neutronic Calculations

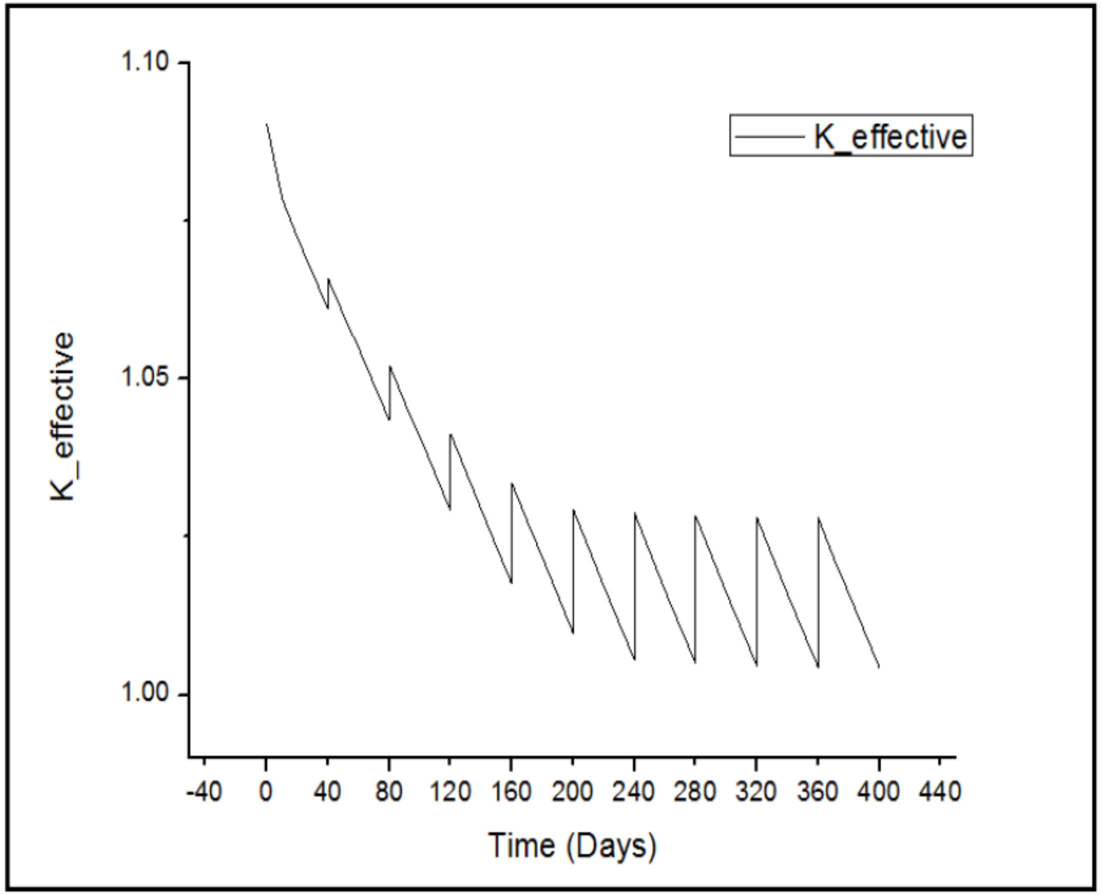
- Neutronic Analysis
  - Deterministic and
  - Probabilistic
- Neutronic Calculation line
- The Computer Codes
  - WIMSD
  - CITATION
  - MCNP



Results

The effective multiplication factor for the first equilibrium core of PARR-1

- It shows values at BOC and EOC for 10 full power day cycles, with cycle length of 40 days.
- It shows that the equilibrium cycle appear at cycle number 6, which begins after 200 days and ends at 240 days.
- At the BOC **Keff** is equal to 1.02998 and reactivity is 2910.6 PCM and at EOC equal to 1.00647 and reactivity is 642.5PCM.



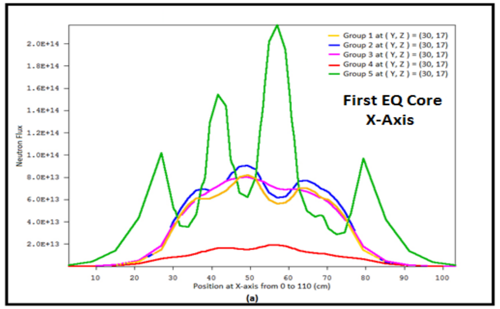
Comparison between the effective multiplication factors calculated with MCNP and CITVAP codes

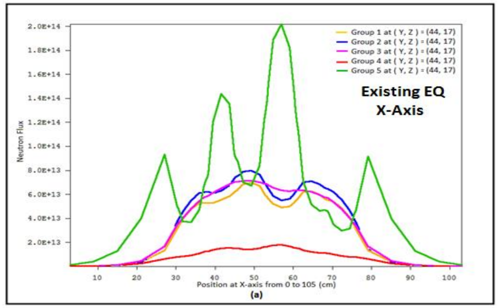
- This results obtained by burning the fresh first equilibrium core of PARR-1 for 40 days with a power of 9 MW in burnup steps of length 10 days.
- The results show variation in the percentage difference that are shown in the last column of.

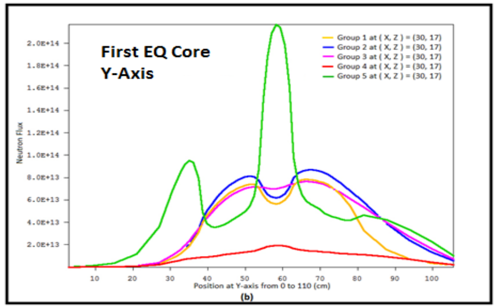
Step Number	Step (Day)	K_{eff}		Percentage Difference (%)
		MCNP	CITVAP	
0	0	1.14055	1.09045	4.392617597
1	10	1.09509	1.07861	1.504899141
2	20	1.08552	1.07237	1.211400988
3	30	1.07675	1.06701	0.904573949
4	40	1.06985	1.06107	0.820675796

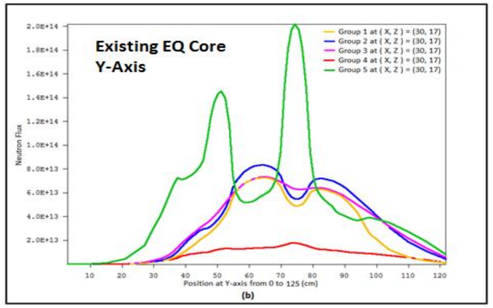
- It indicates that, calculations with the MNCPX code give higher values than that calculated with the CITVAP code by an amount of 1.8 %.

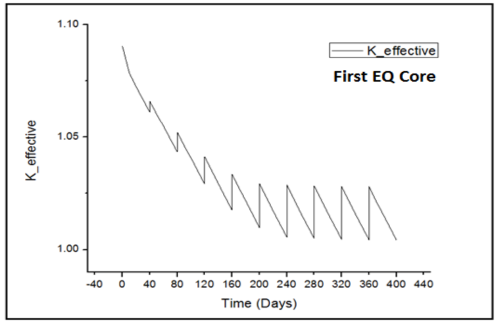
Flux Calculations

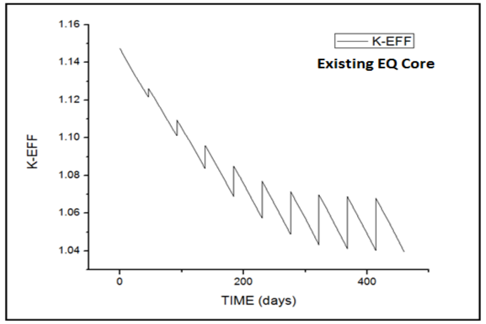


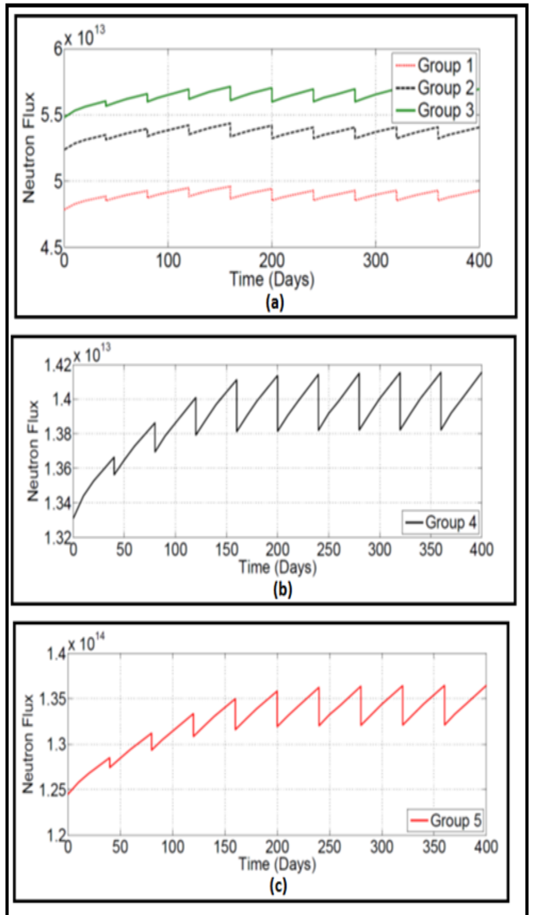




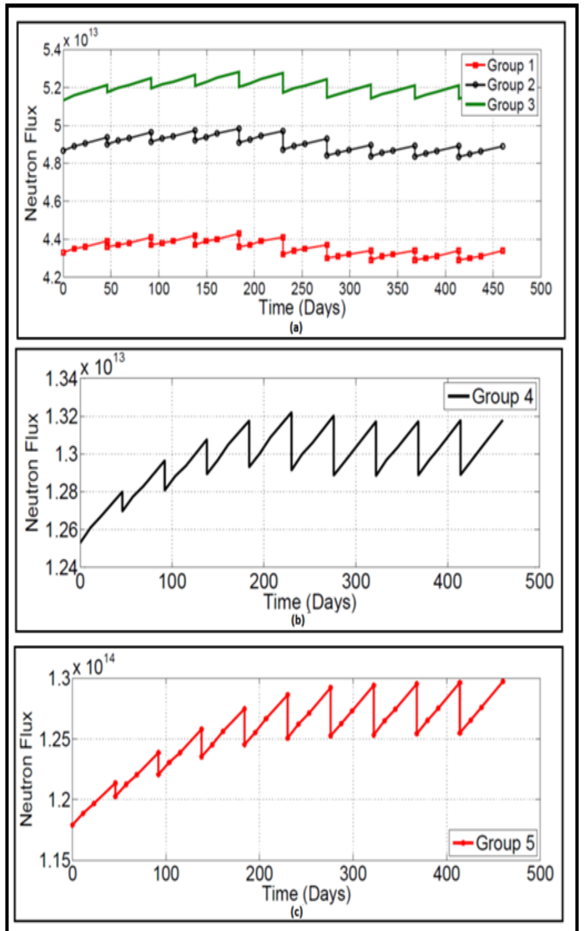








First EQ Core



Existing EQ Core - Central IR Position

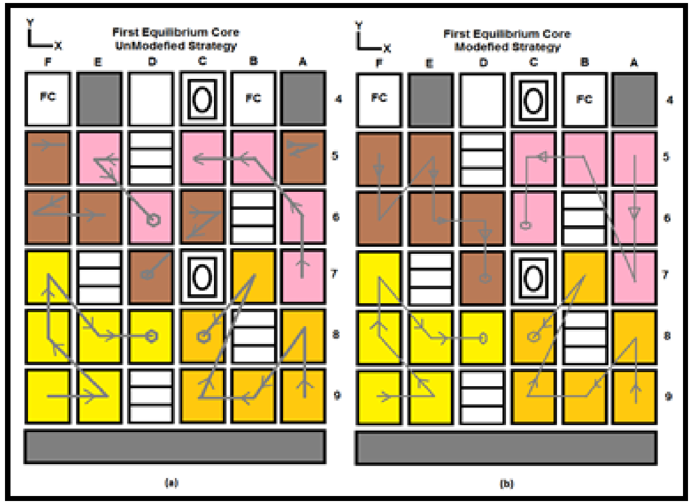
Shuffling Strategy

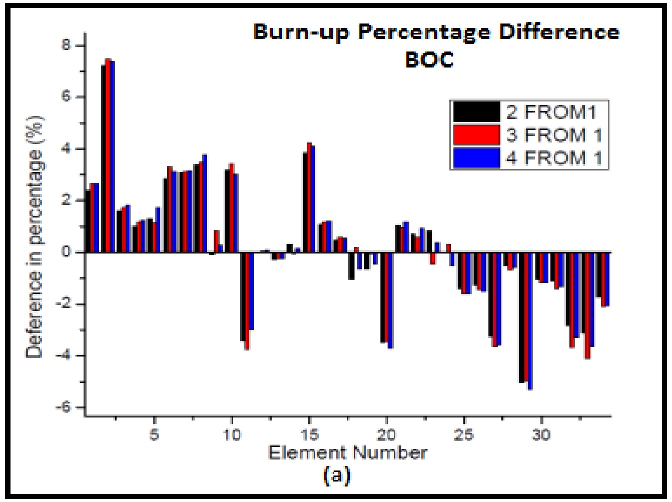
Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
F5	A7	A9	F9	4.43	5.34	4.79	4.98
A5	A6	A8	E9	4.1	4.98	5.42	6.45
F6	B5	B9	F8	5.16	5.41	6.14	5.56
E6	C5	C9	F7	6.67	6.23	7.12	5.91
C6	E5	B7	E8	8.27	5.68	7.76	7.19
D7	D6	C8	D8	9.04	7.45	9.02	8.16
Original Strategy				37.67	35.16	40.25	38.25

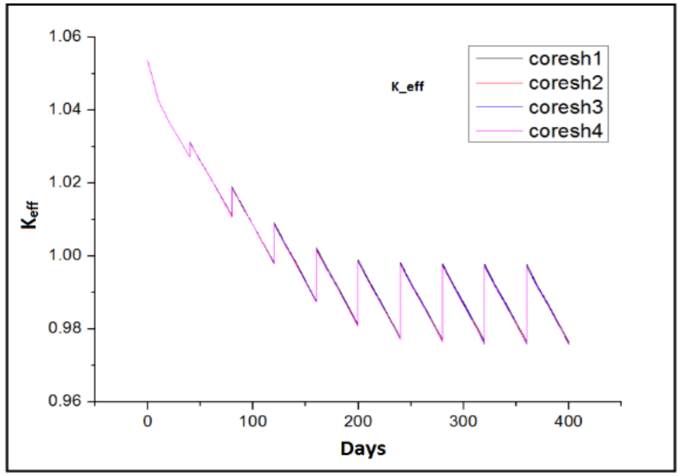
Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
A5	F5	A9	F9	4.1	4.43	4.79	4.98
A6	F6	A7	B5	4.98	5.16	5.34	5.41
A8	F8	E5	F7	5.42	5.56	5.68	5.91
B9	C5	E9	E6	6.14	6.23	6.45	6.67
C9	E8	D6	B7	7.12	7.19	7.45	7.76
D8	C6	C8	D7	8.16	8.27	9.02	9.04
Modified Strategy 1.1				35.92	36.84	38.73	39.77

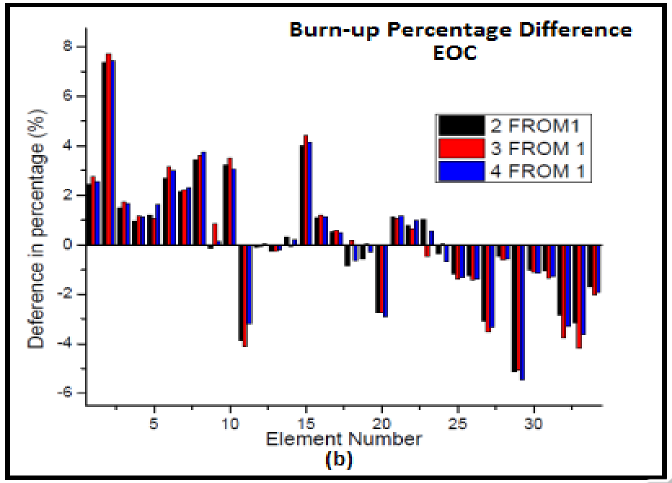
Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
A5	F5	A9	F9	4.1	4.43	4.79	4.98
B5	A7	F6	A6	5.41	5.34	5.16	4.98
A8	F8	E5	F7	5.42	5.56	5.68	5.91
E6	E9	C5	B9	6.67	6.45	6.23	6.14
C9	E8	D6	B7	7.12	7.19	7.45	7.76
D7	C8	C6	D8	9.04	9.02	8.27	8.16
Modified Strategy 1.2				37.76	37.99	37.58	37.93

Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
A5	F5	A9	F9	4.1	4.43	4.79	4.98
F6	A6	B5	A7	5.16	4.98	5.41	5.34
A8	F8	E5	F7	5.42	5.56	5.68	5.91
C5	B9	E6	E9	6.23	6.14	6.67	6.45
C9	E8	D6	B7	7.12	7.19	7.45	7.76
C6	D8	D7	C8	8.27	8.16	9.04	9.02
Modified Strategy 1.3				36.3	36.46	39.04	39.46









Conclusions

- **First**, Many factors will contribute to the calculation accuracy. Geometrical Model and approximations, meshing , numerical techniques, homogenization and condensation,
- **Second**, parameters consideration was different for Keff, flux and burnup.

- The **results indicated** under estimation when using the deterministic package and over estimation by using the probabilistic Monte Carlo codes.

Thanks for your attention!